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Mechanics of magnetic storms and particles in the inner magnetosphere

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Magnetic storms are known to occur when the southward component of the interplanetary magnetic field (IMF) lasts for a few hours and more. The most common manifestation of magnetic storms is the development of the ring current. The convection electric field plays an essential role in transporting the seed ions from the near-earth plasma sheet to the ring current. Relativistic electrons, however, show a different behavior. In some cases, the differential flux of relativistic electrons decreases during the storm main phase, and recovers during the storm recovery phase. Sometimes, the flux exceeds the pre-storm level. The rebuild of the radiation belt is thought to result from two different ways; one is non-adiabatic acceleration of electrons from the keV range to the MeV range. The other one is adiabatic transport of relativistic electrons from the near-earth plasma into the radiation belt. For both cases, transport of particles is a key in understanding the particle environment in the inner magnetosphere. By performing the global magnetohydrodynamics (MHD) simulation and the bounce-averaged particle transport simulation, we have focused on the following 3 unsolved processes regarding particles trapped in the inner magnetosphere in terms of mechanics of the magnetosphere. 1) First, we need to understand the origin of the convection electric field that is responsible for the transport of keV particles. The MHD simulation result shows that no steady convection electric field appears even though IMF is steady. The contribution from the ionosphere is significant in the inner magnetosphere, and that associated with the MHD process is significant in the near-Earth plasma sheet. 2) Secondly, we need to evaluate the influence of substorms on the transport of particles. If the dipolarization is governed by the MHD processes, it will progress in accordance with overall force balance in the magnetosphere, so that the storm-time substorm will be different from an isolated substorm. 3) Thirdly, we need to grasp the particle distribution function in the near-earth plasma sheet because most of them are the direct/indirect source of the ring current and the radiation belt. According to the MHD simulation, the plasma sheet temperature becomes hot when the IMF is steadily southward. The temperature exceeds 20 keV after elapsed time of several hours from the beginning of the southward turning of IMF. The particle transport simulation predicts that the extremely hot plasma sheet gives rise to the enhancement of relativistic electrons in the radiation belt.

Keywords: Magnetic storm, MHD simulation, Inner magnetosphere, Substorm, Convection electric field